ZAMBIA TRADE AND INVESTMENT ENHANCEMENT PROJECT
(ZAMTIE)

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ZAMTIE SUPPORT FOR ZNFU ELECTRICITY TARIFF REQUEST

Prepared

by

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Mission Report
ZAMTIE Project, Support ZNFU Electric Tariff Request

Overview

The main accomplishment has been to develop a proposed tariff that has been submitted to Zesco. This proposal goes well beyond the time-of-day modification envisioned in the order of the Energy Regulatory Board (ERB).

The existing Zesco tariff structure is very simplistic, making customers fit into a few tariff classes. It does not consider the energy load characteristics of individual customers or class of customer. The proposed tariff modification creates mechanisms to develop tariffs that match characteristics of the electric load and match the actual cost of service. These are not "innovative," they are practices followed by utilities worldwide. They also allow Zesco to develop tariffs that result in a more efficient use of their system. The basic principle is that these cost savings be passed through to the customer.

Matching tariffs to cost of service is a basic principle of tariff design. Normally the utility's accounting system provides the cost data for this analysis. Zesco only releases their financial statements, not the chart of account data that would be required for this analysis. Furthermore, based on statements from a number of sources, the organization of Zesco's accounts is not adequate for this purpose. This issue is expanded later in this report.

It is very fortunate that ZNFU engaged Dr. Lemba Nyirenda, a US educated electrical engineer on the faculty of the University of Zambia. He approached the problem from an engineering basis. There is a strong parallel between engineering efficiency and economic optimization. Engineering savings translate into economic benefits, therefore improving engineering performance justifies lower costs. Many of Dr Nyirenda's suggestions have this quality. By taking an engineering approach, reasonable conclusions can be reached while bypassing the accounting system.

As the work progressed it became evident that the tariff issues facing the farmers are more complex than just providing a time-of-day tariff. These proposed modifications go beyond that but other areas need to be addressed in the future. Smaller commercial farmers who are on commercial rate rather than a demand rate get limited relief under this plan. Making the commercial rate a "step" rate, giving larger consumption a reduction in the Kwh charge might be appropriate. This requires accurate cost of service data from Zesco.

Mission Objective

Based on a ruling by the Energy Regulatory Board (ERB), the Zambian National Farmers Union (ZNFU) was given until March 31, 2001 to negotiate a special agricultural tariff. It was implied that this would be based on a "time of day" adjustment for "off peak" consumption. To provide support for this effort, during the first week of March ZNFU made a request to ZAMTIE for technical assistance.

The agr icultural sector requested electric tariff relief. The electric tariffs charged this sector appear high when the load characteristics are considered in relation to the tariff structure available to them. It is desired to obtain a tariff that more closely matches Zesco's actual cost of service to this class of customers. This request is brought by the ZNFU on behalf of the commercial farming sector although the tariff would be available to all agriculture sector customers.

More equable tariffs can be developed that will also improve the efficiency of the utilization of the Zesco system. By developing a tariff schedule that more closely reflects the needs of the customers, better utilization of the existing Zesco system can be obtained by smoothing the system demand and improving the system load factor. Zesco will be able to serve more customers without additional capital investment. The true marginal cost of incremental electric generation of a hydroelectric based system that does not face limitations of water supply is very low; freeing transmission and distribution capacity is very profitable for the utility.

This is not "conservation" in the traditional use of the term. However it will allow the sale of more usable energy without the need for additional system investment. Much of the analysis in this area should be handled the same as traditional conservation investments.

ZNFU Proposed Tariff

A proposed tariff was developed by ZNFU for presentation to Zesco. It has drawn heavily on the engineering analysis of Dr. Nyirenda. His work demonstrated various technical improvements that will improve Zesco's system efficiency. Most of the proposed tariff reductions are pass-through to the customers of these cost savings. This is particularly true of the power factor adjustment.

The proposed tariff has four components; three introduce concepts that provide the mechanism for Zesco to develop a tariff structure that results in a more efficient utilization of the overall system. They also promote matching actual cost of service to the tariff charged. The forth component is intended as a "prod" to improve the quality of service. These components are:

- Power factor adjustment
- Time-of-day tariff
- Diversity factor
- Reversed fixed charges

Power factor adjustment – This is the most significant component and was entirely Dr. Nyirenda's input. It is based on a fairly technical electrical engineering principle. The industry standard is a power factor of between 0.8 and 0.98. Most demand tariffs require compliance within this range or the customer is subject to a penalty. Zesco does not require power factor correction; therefore it is proposed that customers who correct their power factor should be given a lower tariff. Electric loads that create inductance cause poor power factors. Electric motors and electric welding are examples. Adding capacitance to a circuit corrects it. Dr. Nyirenda's presentation to the ZNFU is contained as an attachment to this report. However, in simple terms, power factor is the effect of the "reactive energy" component in an electric load. This is the energy used to maintain the electromagnetic field in a motor (and other uses). It is necessary for the motor to operate but does not do the work (hp or KWh) represented by the rotation of the motor. Adding capacitance to the circuit can offset reactive energy. This lowers demand at the source and also frees up system capacity for the utility. The benefit of the lower system capacity should be passed on to customers who improve power factors.

Off Peak Tariff – Introduces an off peak tariff between the hours of 22:00 and 6:00. This is the time of day tariff that was originally envisioned in the ERB ruling.

Diversity Factor – This introduces an important tariff concept. The utility will need to undertake system analysis to determine the diversity factor for a class or set of customers. In the US, the terminology used is coincidence factor which is the reciprocal of the diversity factor. Demand charge is divided by the diversity factor. The coincidence factor represents how nearly the peak demand of a customer or class of customers matches the system demand.

Reverse Fixed Charges -Introduces two penalty charges for:
(1) quality of supply, i.e. low voltage or surges that damages equipment, and (2) a frequent power cut-off charge to compensate for power outages. Also introduced (as an alternative) is an interruptible tariff with the active energy component half of the regular tariff. In the latter case, there is an *Excess Maximum Demand Charge* – Basically a customer should not exceed the maximum kva allowed for the class of service, which has determined the size of transformer installed. Customers can avoid this charge through various demand side reduction actions.

The proposal presents complex technical issues. Costs and benefits to both the farmers and Zesco must be quantified. In particular, fairly good estimates of the capital costs, including installation, which will be incurred by farmers to meet the requirements of the tariff, need to be made. Although the financial return to the farmers appears high, this is still a capital budgeting issue that requires allocating funds for its inception. It needs to be kept in mind that the current bank interest rate in Zambia is near 50%. It has been verbally proposed to Zesco that the utility bear the cost of power factor correction and special metering requirements to implement these changes.

Another suggestion is to approach the World Bank and have these investments funded under the distribution rehabilitation component of their loan. It has been accepted practice in North America and Europe to allow a utility to make conservation investments at customers' properties rather than expand system capacity. The situation in Zambia meets this criterion.

This tariff proposal is being presented as a "farmers tariff." A problem may be that it appears *too good*. It may be difficult to sell this as a tariff that only applies to the agricultural sector. If manufactures claim they also qualify, Zesco might perceive the short-term revenue loss as too great. They should however recognize the long-term benefits. The power factor component would take time to have a great impact. The farmers would need time to understand the requirements of the tariff, decide to make the investment and get the equipment installed. Reducing the size of the power factor component of the tariff reduction or phasing it in, will have a detrimental effect on the financial benefit of the tariff change to the farmers. Also, if they have to bear the full cost of the required investment it might result in many deciding against the investment to improve their power factor.

It must be emphasized that the proposal does not give the farmers any special treatment. The proposed reductions are based on cost of service. The reduction only reflects a passthrough of cost reductions. The fundamental position is that the existing tariff overcharges farmers.

Meetings with Zesco

As detailed in an appendix, arranging meetings or even having contact with Zesco has been difficult. Early in this period, ZNFU indicate that they had conversations with Zesco staff who said they were preparing a tariff proposal. Just as they were about to deliver it, the decision was made to have it reviewed at a higher level. The proposed tariff was never delivered. Dr Black and Dr. Batt finally met with Dr. Akapelwa to have a general conversation on basic tariff issues on March 29. On March 30 Mr Zyambo, Mr. Mwila, Dr. Nyirenda and Dr. Batt went to meet with Mr. Conger and Mr. T. Mwale to start discussing the new tariff. After a delay, Mr. Mwale met briefly to say the due to budget preparation efforts, the meeting could not take place. Dr. Batt did have a short meeting with Ms. Betty Sombe, Director of Finance, on April 4. On April 5, Mr. Zyambo, Mr. Mwila, Dr. Nyirenda and Dr. Batt met with Mr. Conger, Mr. T. Mwale and Mr. H. Mwale to actually discuss a new tariff. Zesco did not have a proposal. ZNFU did not want to formally present their proposal until it was presented to a group of farmers the following Monday. Dr. Nyirenda verbally presented the major points of the ZNFU tariff. The Zesco representatives appeared surprised at the extent of the proposal. A meeting was scheduled for the following Thursday, April 12. That meeting was cancelled but rescheduled for Tuesday, April 17. ZNFU formally submitted their tariff proposal to Zesco during the week.

The April 17 meeting was attended by Dr. Batt, Dr. Black and Mr. Clayton, a ZNFU Board member. Zesco had the same representatives. Zesco had no formal response, stating they did not receive the ZNFU proposal until Thursday. They did indicate that their view was the ERB only authorized discussions of a time of day tariff. Mr. Clayton brought up the issue of quality and reliability of service. Little progress was made. Zesco stated that they would be able to formally respond in a week to ten days but no date was set for the next meeting.

Dr. Batt returned to the US the afternoon of April 17.

Meetings with Farmers

Two meetings were held with members of ZNFU. The first presented the tariff proposal to ZNFU's Board of Directors. It was generally well received. The main comments were in the area of the cost to farmers for metering and improving power factor and the quality and reliability of service issue. The second meeting was with a group of ten farmers representing all geographic regions of Zambia. Their farms covered a wide range of crops and farm size. They also were concerned regarding the cost of metering and power factor correction. Their most important concern appeared to be quality and reliability of service. They also expressed the view that a time of day tariff would benefit relatively few farmers. There was also concern that the tariff proposal would not help the smaller commercial farmers that are on the commercial tariff.

Zesco Accounting and Disclosure

Access to Zesco's accounting system was not obtained; as indicated above, there has only been limited contact with Zesco. The fiscal 2000 (March 31, 2000 close) audited financial statements were provided. The 2001 fiscal year had just ended and financial statements were not available. The following assessment is mainly based on second-hand reports but is believed to be accurate.

The fiscal 2000 audited statements were extremely qualified by the accounting firm of Deloitte & Touche. Quoting from the auditors letter:

"Limitation in Audit Scope

- The core accounting systems of the company are the Customer Information System (CIS) and Accounting and Financial Management Information System (AFMIS) which were introduced in February 1998. These systems have not operated to a satisfactory level since inception. As a result, at the end of each financial year management is compelled to carry out many procedures outside these systems and to find innovative and unorthodox ways of extracting, analysing and manipulating data from them in order to prepare financial statements. Such procedures of extraction are by their very nature prone to human error. Effectively, the integrity of these systems has not yet been fully established and therefore it is not possible to have adequate confidence in their output."

The letter concludes:

"In respect alone of the limitation on our work relating to the computerized accounting systems

- We have not obtained all the information and explanations we consider necessary for the purpose of our audit; and
- Proper accounting records have not been kept."

The manager of finance indicated that this was mainly a software problem and would be corrected with improvements in that area. However, the audit comments refer to problems that occurred over a year ago and, although improvements may have been made, there are still serious accounting problems. Furthermore, there are indications that fundamental problems with the basic accounting system exist. An electric utility is a fairly basic business. There are three main functional areas; generation, transmission and distribution. The accounting system should reflect this, producing cost and revenue data for each. There may be secondary divisions representing regional or other appropriate subdivisions. Asset accounts should follow the same arrangement with sound cost allocations used when necessary.

Although costs based on these areas can be obtained from Zesco's accounting data, they are not readily available. The ERB can request such data but they must rely on Zesco's analysis not direct access to the appropriate accounts for this information.

The Zambia Privatization Board can not obtain the value of the assets dedicated to the copper industry contract. This reflects not only the organization of the accounting system but also the level of disclosure.

Zesco releases to the public its audited financial statements and an annual report. This is inadequate for a regulated utility, particularly when the ownership is the government. The disclosure in its financial statements is minimal. There is no breakdown of operating expenses or assets.

Accounting reform must include the following areas:

- The basic level of accounting competency must be improved. Accounting data must be reported accurately and on a timely basis. Audited financial statements should never be "qualified" especially to the level of the fiscal 2000 results.
- The accounting system and chart of accounts should accurately portray the business activity. Key functional areas should be reflected in the chart of accounts and not require special analysis to break the data out.
- Filings with the ERB should be at the chart of accounts level and tariff decisions only justified by publicly disclosed accounting data, This could entail data at a level below the chart of accounts.
- The bulk sales contract with the copper industry should be treated as a tariff and the details of it published as part of Zesco's tariff structure. Any future bulk sales agreements should receive similar treatment.
- Accounting controls and financial controls must be improved. Accounting controls ensure a verifiable audit trail. Even with software problems, account coding and data entry should be correct. Financial controls provide the system that ensures actions approved in the planning and budgeting process are enacted and meet financial targets. These controls must cover the whole cycle from planning, budgeting, approval, execution and review.

Zesco has problems that go beyond the accounting system, however the inadequate accounting system will make it difficult to analyze them. Zesco starts out with very low generating costs but costs to end-users are not particularly low. The weight of the evidence indicates that the high costs are in the distribution function. In part this must reflect the old system that needs repair. The distribution function also appears to be over staffed and poorly managed. Not only is this reflected in the costs but also the quality and reliability of service.

Zesco officials like to cite a study by SwedePower (funded by the World Bank?) which, based on long-run marginal costs the current tariffs are too low. On theoretical economic grounds long-run marginal costs present a strong case. They represent an estimated replacement cost, however the economic assumption *ceteris paribus* is strongly invoked. Long-run marginal costs assumes constant technology however except for periods of very high inflation, technology improvements have exceeded inflation. Historical costs may have a bias towards undervaluing assets but long-run marginal cost has a bias towards overvaluing. The periodic revaluing of assets picks up much of the historical cost under valuation.

Growth and demand in relation to profitability seems to be of low concern. Approximately 40% of current sales are through the copper industry bulk sales agreement. This contract has been criticized as being too favorable to the copper industry. Apparently it does not provide the target 6% return on assets to Zesco. It must be accepted as a "done deal" and part of Zesco's operations for fifteen years. It is much better than the situation that existed before; Zesco is being paid. The stability of this cash flow should allow Zesco to concentrate on other issues.

The remaining 60% of sales have significant problems. Collections still are very bad. Sales to government agencies apparently are being paid but slowly. Low income residential customers are not paying on time but they are being cut off for non-payment. The lowest "lifeline" tariff is a subsidized rate as is rural electrification. There is significant theft (non-technical losses) of electricity in the residential area. The townships around Lusaka have been targeted for electric service but these populations are only marginally in the cash economy. An important consideration is that no more than 18% of Zambian residents have access to electricity.

Zesco appears to have a long way to go to become commercially viable. Privatization of the distribution sector at this time would probably require significant subsidies from some source as well as forgiving the investment required to rehabilitate the system.

Automatic Tariff Adjustment Formula

The basic premise of the ATAF is reasonable; the revenue of Zesco must maintain parity in real terms. However there are areas of this adjustment that need to be questioned. This adjustment formula has two components: one for international inflation adjusted for changes in the Kwacha vis-à-vis the U.S. dollar and the other to reflect local inflation.

The electric sales to the copper industry are subject to a separate adjustment agreement and are not subject to the ATAF. A problem area is that details of this agreement are not considered public information. The issue raised in the accounting reform section is important here. Capital assets and expenses relating to the copper operations must be excluded from any ATAF determination. The ERB should insist on an audit of these specific accounts by an independent accounting firm to establish a base line for these calculations.

For the current adjustment period, the foreign exchange adjustment appears to be moot. The recent strengthening of the Kwacha may actually make this component favorable, with a slight downward impact. The weighting of the foreign exchange component is currently 70%. This is based on the expenditures by Zesco for foreign items. There is discussion of dropping this to 60%. At the current exchange rate, this would have an unfavorable impact on the tariff adjustment.

There are some fundamental problems with the adjustment component. It tends to put pressure on the government to maintain a strong Kwacha, which is not always the best policy. It makes Zambian exports less competitive. The adjustment is against the US dollar. Because the dollar has been very strong against other currencies, this overstates the needed adjustment. In the fiscal 2000 Balance Sheeet all foreign denominated loans were in Euro Zone currencies. The main trading partners of Zambia use Pounds or Euros. Purchases under the World Bank loan will probably be in US dollars but those contracts have not been awarded so they are not subject to international inflation. Furthermore, except for a telecommunication system, none of the loan related work is completed or put in service. Work in progress should not be part of the tariff base; by basing the ATAF on that work a basic principle of tariff design is violated. It is also good economic policy to remain competitive with local trading partners and forcing a strong Kwacha is undesirable in this regard.

The change in the local inflation rate is the basis of the second component. The automatic pass through of the local inflation rate change, in the form of utility charges, in itself contributes to inflation. The charge has no basis in the actual cost increases at Zesco and provides no incentive for Zesco to keep its cost increases under the inflation rate. Based on fiscal 2000 data, one-third of its operating expenses is depreciation which, as a fixed charge, should not be subject to a tariff increase. Furthermore, Zesco has a program of periodic revaluation of assets, which makes inflation adjustments double counting.

It is proposed that an incentive adjustment be initiated. Zesco would be allowed an increase based on their actual cost increases capped at the local inflation rate. However, acceptable publicly disclosed accounting of these costs must be in place before the proposed adjustment should be allowed. As an incentive, Zesco should also be allowed an increase of one-half the difference between their costs and the local inflation rate. It is further suggested that part of these funds be allocated to a bonus plan and shared by all management and employees.

Other Issues

Zambia has recently undergone significant changes in its economy. This has included the privatization of the copper industry, liberalization of tariffs and trade policy and is undergoing a major rehabilitation of the electric power sector. These events require a review of the energy sector policies to provide a unified and equable approach for future development. This review should encompass the whole energy sector, looking at both supply and demand. Furthermore, the relationship of a rational energy policy to overall economic policy should be considered.

First, some general characterizations of the Zambian energy sector. The country is blessed with abundant, cheap hydroelectric power resources. All generation is operated by Zesco, the government owned utility. Distribution to the copper industry is handled by a private company under a bulk sales agreement. There are some small hydroelectric units and small diesel units that are not connected to the grid. Fuel resources are limited to one coal mine which apparently is closed due to a failed privatization attempt. Efforts are being discussed to again offer this property. Liquid fuels come from one local refinery using imported crude and imported product. Zambia’s location in the middle of Africa makes transport costs high. There has been little effort in the areas of renewable and unconventional energy resources although there seems to be a large potential in this area.

Macroeconomic policy has had an impact on the energy sector. At the same time the world energy markets have had an impact on the Zambian economy. The domestic inflation rate has been high, around 30% the past year. This is partly the result of higher world oil prices that led to expanding the Zambian money supply. Petroleum imports were partly financed by expanding the money supply which in turn lead to higher inflation and a devaluation of the Kwacha. Recent actions have strengthened the Kwacha which may have a near-term favorable impact on inflation. However, this has lowered the incomes of farmers with export crops and in general is detrimental in promoting exports.

Fiscal policy has put a significant tax burden on energy, particularly liquid fuels. Electric power is subject to a 10% rural electrification fee and the 17½% VAT. This is not excessive, however the nature of a value added tax compounds any overcharges in the basic tariff. Until recently, the rural electrification fee was being used as general government revenue, not for its intended purpose. Unfortunately for Zesco, rural electrification expenditures have paid for some of the isolated diesel generators. Although meeting a social need, these units can not recover their variable costs through tariffs, resulting in a subsidy paid by Zesco. The bulk sales agreement to the copper industry is not subject to VAT or the rural electrification fee. Copper exports also are exempt from VAT.

Liquid fuels bear a greater tax burden. There is an import duty, excise tax, road tax and then the VAT is applied. Farmers must pay the road tax on fuel consumed by their fixed equipment and farm tractors. Imported petroleum products are subject to a 25% duty, apparently to protect the domestic refinery

Liquid Fuels

Liquid fuels have a combination of problems. With no indigenous petroleum reserves, the logistics of supplying a country in the center of Africa is a significant problem. There is a small refinery capable of supplying Zambia's needs. It has recently been rebuilt following a major fire. Due to this rebuilding, it probably is reasonably state-of-art however small refineries inherently have limitations. Crude is supplied by pipeline from Dar-es-Salam. The refinery was recently shut down again due to financial problems that prevented payment for the crude oil. During these periods when the refinery was shut down, product was shipped in truck. The refinery operation is protected from competition from imports by a 25% duty on petroleum products.

The structure of the industry appears to be the major problem, compounded by state ownership. Apparently there are three entities involved: a refinery, an entity that imports crude oil and a distribution operation. Retail sales appear to be in the hands of private firms. Recently the refinery was shut down because the importing operation did not have the funds to pay for crude oil waiting to be shipped to Zambia. It has been proposed to allow private groups to import crude oil for "toll processing" at the refinery.

The whole liquid fuels sector needs to be evaluated with reorganization and privatization a goal. The total tax burden on liquid fuels needs to be assessed in light of the reduction of trade tariffs in other areas. This includes evaluation of the tariff protection from imported petroleum products given the refinery.

Recommendations

- Push for accounting reform at Zesco. It may be best to do this through the World Bank since the Bank implied that this was part of the needed institutional reform for the sector. This must include greater disclosure and proper financial controls. It will be difficult to make "cost of service arguments without it; the engineering approach can only go so far.
- Continue to push the tariff proposals that have been presented. They have a sound basis and will be beneficial to Zesco in the long run. It would be easier to "sell" them with an adequate accounting system. Modifying the commercial tariff to provide a lower kwh "step" for higher consumption within the tariff classification also should be considered but the accounting data constraint is even more limiting here.
- The liquid fuels are needs help. It probably requires major restructuring and, if viable, privatizing. The cost implications of the current policy should be evaluated as a starting point.
- Overall economic policy needs to be assessed as it impacts on the energy sector *and* the impact of the energy sector on economic performance must be evaluated. Policy in both areas are interconnected. This has strong implications for trade and investment issues but may be too complex an issue for the current contract.

Appendix I – Chronology of Mission Inception

Dr. Robert Batt, consultant for ZAMTIE, arrived in-country March 12. During the first week, meetings were held with USAID, ZNFU. Zambia Privatization Agency, Energy Regulation Board, US Embassy Commercial Officer and Mr. Richard Healy representing the Zambian Manufacturers Association. Meetings were also held with senior staff of IMCS, the local partner in the ZAMTIE Project. The meeting with ZNFU was attended by Mr. Ajay Vashee, President, and Mr. A.M. Mwila, economist. Mr. S. Zyambo, Executive Director, was out of town.

At the beginning of the second week a brief memo was sent to Mr. Mwila providing some preliminary approaches to an agriculture tariff and comments regarding the Automatic Tariff Adjustment Formula (ATAF). At this time, Dr. Black was trying to arrange meetings with Zesco officials but was getting no response. At the same time, calls to Mr. Mwila indicated that he was not feeling well and was out of the office.

Finally late on Thursday March 22, Mr. Zyambo returned to Lusaka and phoned Dr. Black. A meeting at ZNFU was arranged for the next day. He also indicated that Mr. Mwila's absence was the result of his being involved in an automobile accident and the lack of response from Zesco was caused by the activities of the end of the fiscal year and budget preparation. During the next day's meeting, Mr. Zyambo provided the terms of reference for the local consultant hired by ZNFU. Dr. Nyirenda is an electrical engineering professor at the University of Zambia and was educated in the United States. He also has experience working for a U.S. engineering consulting firm and is very familiar with Zesco's operations. Mr. Zyambo also stated that a meeting with Zesco had been arranged for early Monday morning.

This was the end of the second week and no substantive work on the tariff proposal had been done. Significant background data had been collected and useful background meetings with various people has been completed. Both ZNFU and

ZAMTIE were working under the assumption that the March 31 deadline set by ERB was firm. The work should have shown much greater progress at this point.

The third week did not start with any greater promise. The Monday morning meeting with Zesco was cancelled. Dr. Black scheduled a meeting with Dr. Akepelwa of Zesco for Tuesday that was also cancelled. A rescheduled meeting on Thursday resulted in Dr. Akepelwa being out of the country. However he returned and a productive meeting with him, Dr. Black and Dr. Batt was held late that afternoon. ZNFU finally arranged a meeting on Friday afternoon with Mr. Conger and Mr. T. Mwale of Zesco to begin tariff negotiations. Mr. Vashee, Mr. Zyambo, Dr Nyirenda and Dr. Batt went to Zesco's office, waited forty-five minutes and were then told in a brief meeting with Mr. Mwale that due to final budget preparation efforts the meeting could not take place.

The first meeting that actually discussed the new tariff took place April 5.

APPENDIX II – ZNFU Special Tariff Proposals

ZNFU SPECIAL TARIFF PROPOSALS
based on
Electrical Engineering Basis Research Report

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FINAL (REV 1, 10.04.2001)

1. Proposed Special Tariff for ZNFU Farmers
To include all farming undertakings affliated with the ZNFU in all tariff categories .

2. Supply Side Electricity Charges

A = Fixed charge per month to cover portion of operating costs

A1 = Fixed charge per month to cover portion of ZESCO costs

Comment 1:
Based on LRMC ZESCO's Electricity Tariff Study

A2 = Fixed reverse -charge to cover a portion of emergency and standby electricity supplies and/or production losses due to frequent unplanned power outages exceeding X hours/month

Comment 1:
To address reliabiliy of supply problems sited in ZNFU Position Paper attachments. This charge to should be in the order of the value of un-served energy to the customer per ZESCO Electricity Tariff Study

A3 = Fixed reverse -charge to cover part of repair or replacement costs of equipment damaged due to verifiable voltage, frequency and power quality inadequacies

Comment 1:
To address quality of electricity supply problems ZNFU Position Paper attachments.

B = Time of Use Active Energy Charge

Comment 1:
Request in ZNFU Position Paper Request, Standard Practice internationally as in Appendix D for "Economy Tariff"

B1 = Day time Peak Energy Charge ZK/kWh

B2 = Day time Off-Peak Energy Charge ZK/kWh

B3 = Night time Peak Energy Charge ZK/kWh

B4 = Night time Off-Peak Energy Charge ZK/kWh

C = **Reactive Energy Charge**

<u>Comment 1:</u>

Power Factor Correction can reduce MD kVA Drastically thereby eliminating the need for MD Capacity Charges; See Appendix B3. Therefore for deserving demand points, with adequate Power Factor Correction on a farm, the MD Capacity Charge is not necessary, only the kVARh consumption charge would be necessary. This is because the Maximum Load demand will always be below the supply Transformer rated kVA defined in Appendix B1

C1 =Direct Reactive Energy Charge ZK/ kVARh

OR

C2 = Low Power Factor Penalty Charge ZK/ Net kVAR

Net MD kVAR = MD Meter kVAR – kVAR at Ref–Power-Factor

Reference Power Factor = 0.80

D = **Distributed Net-Maximum-Demand Peak Capacity Charge**

= **DG (Generation) + DT (Transmission) + DD (Distribution)**

Comment 1:

See Appendix B3 and Appendix B5.

This practice would require ZESCO to begin measuring the simultaneity factors at declared reference Generation Nodes, Transmission Nodes and Main Distribution Nodes for a designated groups of customers. If this was done to day there would be more than 50 percent reduction in MD Charges per customer group

D1 = Day time Peak MD Charge ZK/ kVA

D2 = Day time Off-Peak Net-MD Charge ZK/ Net kVA

D3 = Night time Peak MD Charge ZK/ Net kVA

D4 = Night time Off-Peak Net-MD Charge ZK/ Net kVA

Net MD kVA = MD Meter peak kVA – MD Meter off peak kVA

MD Meter Peak < TX Rated Design Load on Transformer Natural Cooling Rating

Diversity Factor = 1/ (Simultaneity Factor)

DG (Generation) = (Incremental Generation Capacity Charge)/ (Generation Diversity Factor)

DT (Transmission) = (Incremental Transmission Capacity Charge)/ (Transmission Diversity Factor)

DD (Distribution) = (Incremental Distribution Capacity Charge)/ (Distribution Diversity Factor)

Comment 2:

1) MD KVA Charges can be reduce first by raising the power factor , secondly by raising the loadfactor by cyclic load scheduling,and thirdly by switching off un-necessary loads , and fourthly by basing charges on the NET-kVA Maximum Demand. See Appendix A8 .

2) The highest kVA bills result when both the Power factor and the Load Factor at a demand point are low. See AppendixB3.

3. ZNFU Energy Conservation Peak Tariffs

	A1	B1	C1	C2	D1
Electricity Tariff Charges In Zambian Kwacha (ZK) **1 US$=3600 ZK**	**Fixed Charge per Month**	**Active Energy Charge per kWh**	**Reactive Energy Charge per kVARh**	**Low Power Factor Net-Reactive Power Charge per kVAR Per month**	**Peak Capacity(MD) Charge per kVA per Month**
Un-metered Residential					
L1 up to 2A	4,200 7.2 % of MD1				
L2 above 2A	15,200 26% of MD1				
Metered Residential					
R1 up to 300 kWh		60 71% of MD1			
R2 301-700 kWh		85 100% of MD1			
R3 above 700 kWh	5000 8.6% of MD1	140 164% of MD1			
Commercial	O601 hours to 2159 hours				
	25,000 43% of MD1	140 164% of MD1			
Social Services	O601 hours to 2159 hours				
Water Pumping, Street lighting, Hospitals, Churches, Schools, Orphanages.	20,000 34% of MD1	116 136% of MD1			
Maximum Demand	O601 hours to 2159 hours				
MD1 Capacity up to 300 kVA	58,165 100% of MD1	85 100% of MD1			5,939 100% of MD1
MD2 Capacity Between 300-2000 kVA	116,330 200% of MD1	73 86% of MD1			11,111 187% of MD1
MD3 Capacity Between 2000-7500 kVA	232,660 400% of MD1	54 64% of MD1			16,754 282% of MD1
MD4 Capacity above7500 kVA	465,320 800% of MD1	45 53% of MD1			16,847 283% of MD1

4. ZNFU Energy Economy Off-Peak Tariffs

	A1	B1	C1	C2	D2
Electricity Tariff Charges In Zambian Kwacha (ZK) **1 US$=3600 ZK**	**Fixed Charge per Month**	**Active Energy Charge per kWh**	**Reactive Energy Charge per kVARh**	**Low Power Factor Net-Reactive Power Charge per kVAR Per month**	**Peak Capacity(MD) Charge per Net-kVA per Month**
Un-metered Residential					
L1 up to 2A	4,200 7.2 % of MD1				
L2 above 2A	15,200 26% of MD1				
Metered Residential					
R1 up to 300 kWh		60 71% of MD1			
R2 301-700 kWh		85 100% of MD1			
R3 above 700 kWh	5000 8.6% of MD1	140 164% of MD1			
Commercial	2200 hours to 0600 hours				
	25,000 43% of MD1	140 x 50% (PF>.8)			
Social Services	2200 hours to 0600 hours				
Water Pumping, Street lighting, Hospitals, Churches, Schools, Orphanages.	20,000 34% of MD1	116 x 50% (PF>.8)			
Maximum Demand	2200 hours to 0600 hours				
MD1 Capacity up to 300 kVA	58,165 100% of MD1	85 x 50% if interruptible		Negotiable percent of D1	5,939 x 50%
MD2 Capacity Between 300-2000 kVA	116,330 200% of MD1	73 x 50% if interruptible		Negotiable percent of D1	11,111 x 50%
MD3 Capacity Between 2000-7500 kVA	232,660 400% of MD1	54 x 50% if interruptible		Negotiable percent of D1	16,754 x 50%

MD4 Capacity above7500 kVA	465,320 800% of MD1	45 x 50% if interruptible		Negotiable percent of D1	16,847 x 50%

5. ELECTRICAL ENGINEERING BASIS RESEARCH REPORT

EXECUTIVE SUMMARY

1. INTRODUCTION
1.1 Electricity Tariff Adjustment
1.2 Terms of Reference
1.3 Methodology
1.4 Presentation

2. ZESCO TARIFF ANALYSIS
2.1 Basis and Assumptions
2.2 Structure
2.3 Distribution of Costs
2.4 Metering and Billing Charges
2.5 Comparisons with International Tariffs

3. ELECTRICITY UTILIZATION ANALYSIS
3.1 Categories of Agriculture Undertakings
3.2 Summary of Electricity Bills
3.3 Cost of Production Decomposition
3.4 Electrical Load Sequencing and Load Factors
3.5 Reactive Power Consumption and Power Factor Correction
3.6 Effects and Frequency of Unscheduled Power Cuts

4. SUPPLY-SIDE COST REDUCTION ACTIONS
4.1 Quality of Supply
4.2 Frequent Power-Cut Damage
4.3 Excess Maximum Demand Charge
4.4 Diversity Factor
4.5 Off-Evening Peak and Seasonal Tariffs

5. DEMAND SIDE COST REDUCTION ACTIONS
5.1 Systematic Load factor Management and Power Quality Management
5.2 Distributed Power Factor Correction
5.3 Site specific Optimal Mix of Tariffs

6. CONCLUSION AND RECOMMENDATIONS
ACKNOWLEDGEMENTS
BIBLIOGRAPHY

APPENDIX

Appendix III – ZNFU Engineering Basis for ZNFU Tariff Proposals

DRAFT INAL REPORT (Rev 5, 11.04.2001)

ELECTRICAL ENGINEERING BASIS
FOR ZNFU SPECIAL TARIFF PROPOSALS
FOR ZAMBIA'S AGRICULTURE SECTOR

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. INTRODUCTION

Electricity Tariff Adjustment

Background

On 29th September 2000, ZESCO applied to the Energy Regulation Board (ERB) for its intention to revise retail electricity tariff by 16 % based on the automatic tariff adjustment formula (ATAF). This was in accordance with the provisions of Section 8 of the Electricity Act, CAP 433 of the Laws of Zambia. Objections to the revision of the electricity tariffs were received from the Zambia National Farmers' Union (ZNFU) and the Zambia Consumer' Association. The objections and ZESCO's reactions thereto were raised at a public hearing held on 24th November 2000. The Zambia Consumers' Association requested for the ATAF to be scrapped. The positions of the ZNFU and ZESCO, the rulings of the ERB, and observations of the Power Rehabilitation Project World Bank mission are summarised in Appendix E.

1.5 Terms of Reference

The purpose of this investigation is to present a research paper on the electrical engineering basis for a special tariff for farmers to be developed by ZESCO in line with ERB's rulings and the ZNFU position.

1.6 Methodology

The steps involved in developing the quantitative basis for the special tariff proposals were as follows:

1) Assemble the relevant electricity consumption information for the agricultural sector (Appendix A).
2) Present a mathematical model for reducing unnecessarily high electricity bills (Appendix B).
3) Analyse electricity utilization characteristics of representative farming categories (Appendix C) .
4) Conduct a limited world search for special tariffs specially designed for farmers (Appendix D).
5) Analyse the new ZESCO tariff structure and implications on the various categories (Appendix A10).
6) Specify supply-side and demand-side tariff adjustment activities based on Appendix A to D.
7) Recommend special tariff proposals for farmers based on specific supply-side and demand-side tariff adjustment activities.

1.7 Presentation

The report consists the following sections: Introduction (Section 1), ZESCO tariff analysis (Section 2), Electricity utilization analysis (Section 3), Supply-side tariff adjustment activities (Section 4), Demand-side tariff adjustment activities (Section 5), Conclusion and Recommendations (Section 6), followed by Acknowledgements, a Bibliography and an Appendix.

2. ZESCO TARIFF ANALYSIS

2.6 Basis

The present 2001 ZESCO tariff shown in Appendix A10 aims at implementing the recommendations of the 1999 “SwedPower Electricity Tariff Study”. This study relies heavily on the information contained in the 1996 “Twenty year Power System Development Plan”. The approved tariff is based on:

1) Projected average costs to reflect the fiancial requirements on the company due to the performance contract with the Government of the republic of Zambia.
2) The projected long run marginal costs (LRMC) of generation, transmission, distribution and supply capacity of national electricity delivery infrastructure.

Currently the cost of electricity purchases by the Distribution and Customer Service Division are less than the total revenue from domestic sales. Thus there is a concerted effort by ZESCO to correct this undesirable economic condition through graduated tariff adjustments. Therefore ZESCO has three primary goals when making changes of its electricity tariffs:

1) Increased revenues to ZESCO.
2) Subsidies for households with weak financial economy.
3) Efficient use of electricity and energy conservation.

2.7 Structure

The electricity tariff in Appendix A10 is divided into five categories, namely : Un-metered residential (Lifeline L1 and L2), metered residential (R1, R2, and R3), commercial , social services, and maximum demand (MD1, MD2, MD3, and MD4). The tariff consists of three components, namely:

1) A fixed charge (A1) which reflects charges for metering , billing and part of the cost of the service line in ZK / month. This charge is independent of consumption.
2) An active energy consumption charge in ZK/ kWh.
   This includes running or variable operating costs which are proportional to the energy output or consumption. This includes variable maintenance costs, output dependent power system operating costs , fuel costs and where applicable a royalty charge per kWh generated.
3) A peak maximum demand capacity charge in ZK/ MD-kVA per 30-minute averaging interval. The peak kVA maximum demand has two components, namely: the peak kW active power maximum demand and the peak kVAR reactive power maximum demand.
   The above maximum demand charge consists of capacity related standing charges which are independent of energy output or consumption. This includes fixed maintenance costs, capacity investment costs, interest, insurance, annual cost of wages and taxes, depreciation, and where applicable a royalty charge per kW per year generated.

2.8 Distribution of Costs and Conditions

The distribution of costs between the consumer categories is fairly sensitive to assumptions concerning power factor, load factor, and simultaneity factors at various generation, transmission and distribution power demand points. The fixed charge is, where necessary, used to get a fair distribution of costs between the customer categories with fairly different consumption patterns. It is also used to get consistency between the various maximum demand tariffs.

Most of the costs for the electricity supply to small customers are fixed. The capacity demand of small customers is not possible to measure on a regular basis for each customer. However, the size of the energy consumption will normally correspond with the utilised capacity. The utilisation of the generation and transmission system for these customers is dependent on the amount of energy consumed. The cost of those parts are mirrored by the active energy charge.

2.9 Conditions for Maximum Demand Tariffs

The SwedPower study outlines the following conditions for maximum demand tariffs:

1) Allowed monthly peak kVAR reactive power demand should not exceed 50% of the monthly peak kW active power demand. This requirement corresponds to a minimum peak demand power factor of 45 % and the peak maximum demand kVA equal to 112% of the magnitude of the peak kW active power demand. The excess reactive power demand shall be charged at 12 US$ per kVAR per year. This is equivalent to imposing a low power factor penalty charge.

2) To give price incentives to the customers to reduce its demand during the evening peak, an off peak tariff should be introduced.

   The capacity component of this tariff should be set be set as follows: The off peak demand exceeding the peak demand during the system peak hours should be charged at only 50% of the capacity charge. The energy charge should be the same as for the regular tariff.

   Such a tariff will require metering equipment where the maximum demand during system peak time is measured, as well as the maximum demand during system off peak time is measured. The fixed charge including the cost for the meter and meter reading will be higher.

3) The large maximum demand customers supplied, preferably those at a service voltage above 11kV, should have the alternative to negotiate the tariff price and other conditions with ZESCO.

4) An appropriate indexation for automatic monthly adjustment of the Kwacha tariffs according to the current US$ exchange rate is recommended.

2.10 Comparisons with International Tariffs

A cursory survey of international tariffs is given in Appendix D. There was no special tariff for farmers as such. The closest is the irrigation tariff category in the United States of America and Canada (Appendix D3). The structure of the ZESCO tariff is similar to that of Eskom in South Africa (Appendix D1). Eskom has a special interruptible power tariff having with a reduced energy charge per kWh. The residential block tariff is similar to that of London Electricity (Appendix D4). Special examples of tariffs which incorporate seasons, peak time, off peak time, and standard time of use are London Electricity (United Kingdon), Eskom (South Africa) and Woodstock (Canada).

ZESA in Zimbabwe uses an automatic tariff adjustment formula based on changes in coal fuel price, diesel fuel price, and exchange rate ZIM$/US$.

ZESCO, ZESA, and ESkom residential have residential block tariffs. However, Eskom tariffs and ZESA industrial tariffs have a fixed charge and an energy charge which are both dependent on the time of use.

6. ELECTRICITY UTILIZATION ANALYSIS

3.1 Categories of Agriculture Undertakings

The undertakings sampled in the agricultural sector are divided into five main categories as shown below. The information requested included:

1) Electrictity bills and consumption statistics for each demand point at a farm for 1999 and 2000 years.
2) Production schedules and percentage of electricity costs to total annual production costs for 1999 and 2000 years.
3) Irrigation and processing sequencing and corresponding monthly load factors.
4) Peak kVA, peak kW, peak kVAR, and peak power factor per month.
5) Negative impacts and frequency of unscheduled power interruptions.

CATEGORY	AGRICULTURAL UNDERTAKING
1. Corporate	Zambia Sugar Plc, Mazabuka.
	Zambezi Ranching, Mazabuka Temba Farm
	Mubuyu Farms, Mazabuka Mpongwe Development Company, Ndola.
2. Large Scale	Ellensdale Farms, Lusaka
	CMR , Kabwe
	J. Y. Estates, Chisamba
3. Horticulture and Floriculture	Agriflora, Lusaka York Farm, Lusaka
4. Processors	Hybrid Zambia Ltd, Lusaka.
	Ross Breeders, Lusaka.
5. Others	Golden Valey Research Trust, Chisamba.

3.2 Summary of Electricity Bills

The summary of electricity bills is in Appendix C. Very few undertakings supplied the information requested in Section 3.1. However, the Mpongwe Development Company supplied the most detailed information. From the data supplied it was not possible to compute the monthly load factors and peak maximum demand power factors.

3.3 Cost of Production Decomposition

The proportion of electricity costs as a percentage of the total annual production cost at agricultural undertakings are shown in Table A3 of Appendix A. Only York Farm gave the above percentages.

3.4 Electrical Load Sequencing and Load Factors

No production schedules and load factors were supplied.

3.5 Reactive Power Consumption and Power Factor Correction

No data on peak kVAR reactive power maximum demand was supplied.

3.6 Effects and Frequency of Unscheduled Power Cuts

No data on the effects of erratic power supplies and un-balanced voltages were supplied.

7. SUPPLY-SIDE COST REDUCTION ACTIONS

4.6 Quality of Supply

Introduce a reverse penalty charge to ZESCO for persistent inadequate quality of supply.

4.7 Frequent Power-Cut Damage

Introduce a reverse penalty charge to ZESCO for persistent inadequate reliability of service of supply. Alternatively introduce an interruptible power supply electricity tariff in areas experiencing very high frequency of unscheduled power supply interruptions.

4.8 Excess Maximum Demand Charge

Introduce an excess peak reactive power charge as outlined in Section 2.4 . Care should be taken that the local transformer rated kVA is not exceeded. See Appendix B3 for correct sizing of distribution transformers.

4.9 Diversity Factor

Apply generation, transmission, and distribution simultaneity factors in computing the total maximum demand kVA charge. See Appendix B5.

4.10 Off-Evening Peak and Seasonal Tariffs

Introduce tariffs incorporating time of use and seasons similar to tariffs mentioned in A ppendix E1, Sections 2.4 and 2.5 .

8. DEMAND-SIDE COST REDUCTION ACTIONS

5.4 Systematic Load factor and Power Quality Management

Reduce your total electricity bill by levelling load factors at each power demand point and maintaining high power quality standards through proper maintenance of electro-mechanical equipment throughout the farm farm. Special care should be taken in validating the integrity of the earthling circuits of all structures and electrical equipment to minimize electrocution of humans and damage due electrical fires.

5.5 Distributed Power Factor Correction

Avoid excess peak maximum demand charges (C2 and D in Appendix A10) by adopting load point power factor correction throughout the farm.

5.6 Site specific Optimal Mix of Tariffs

Select the best mix of tariff categories at a farm that minimizes the total monthly bill being offered by ZESCO.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

ZESCO can contribute significantly to stimulation of the national economy and assist local industry to be regionally competitive. The utility's commercial viability has to be matched by a visibly aggressive drive to improve internal efficiencies

The adoption of a well-articulated Time-of-Use tariff structure would be an important step to encouraging sectors such as farming to actively review consumption practices to the mutual benefit of ZESCO and the consumers.

Certain consumers are constrained by the nature of their operations to consume most of their power during periods of peak demand. Farmers, however, are well placed to shift a significant part of their consumption to periods of minimum demand on the ZESCO system. Activities such as irrigation of winter crops, crop drying and workshop operations are examples.

If the tariff structure can demonstrate significant savings, then the consumers would be compelled to restructure their consumption patterns. The premise for benefits should be efficient energy utilization.

Time-of-use (ToU) tariffs will also benefit the utility in terms of foregone investments in power generation plant. By judicious application of ToU tariffs, the utility can increase its installed customer base and extend the useful life of its installed generating capacity. The demand from farmers and other customers becomes flattened over a long period of time instead of short time peaks.

We have looked at examples of ToU tariffs from other utilities to try and arrive at a proposal for adoption here in Zambia. We have considered selected tariff groups from London Electricity Company and from ESKOM of South Africa.

Both utilities have daily ToU tariffs as well as Seasonal Time of Day Tariff rates. The Appendix D highlights the main features of these tariffs.

The most significant feature is the relative saving enjoyed by consumers by careful planning of their consumption patterns through:

1) Power factor correction;
2) High load factor and off-Peak hours energy use;
3) Distributed peak-capacity-charge reduction due to variations in power system simultaneity factors in generation, transmission and distribution; and
4) Demand Side Management focused on high productivity, energy waste reduction and energy conservation through use of high efficiency electrical equipment such as motors.

6.2 Recommendations

The existing standard tariff should be converted into peak rates for farmers. The off-peak tariff should then be discounted as follows:

Capacity Charge – 50% discount on standard tariffs
Energy Charge – 50% of standard tariffs if interruptible.

ACKNOWLEDGEMENTS

The ZNFU and ZESCO Corporate directotates are acknowledged with sincere thanks for facilitating the data collection and arrangement of meetings with various stakeholders.

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APPENDIX

Appendix A : Agriculture Sector Electricity Consumption Statistics

Table A1 Consumption Forecast

Year	96/97	97/98	98/99	99/00	00/01	01/02
GWh	209	220	231	243	258	273
Percent of Total	2.94	2.95	2.99	3.07	3.20	3.29
Total	7112	7464	7718	7917	8067	8306

Table A2 GDP Growth in Percent

Sector	Base 1997-1999	Scenario 2000-2014
Agriculture	4 %	5 %
Manufacturing	4 %	4 %
Trade	5 %	5 %
Electricity	3 %	4 %

Table A3 Electricity Price Elasticity

Sector	Annual Energy MWh	Electricity Cost Percent of Total Production	Price Elasticity	Estimated Growth in 5yrs MWh
Industrial Power Intense	70,000	10-40 %	-0.5 – 1.0	+100,000
Agriculture Zambia Sugar York Farm Mubuyu Farm	 6 % Annual Growth	5 – 6 % 1.7 % (1999) 2.6 % (2000) --------	-0.2 (two major Consumers)	
Agriflora				
Ellendale				
Mr. Asworth				
Hybrid GART				
Mpongwe D..				
Ross Breeders				
Zambezi R.				

Table A4 Impact of Price Increase on Electricity Demand

Price Increase	Elasticity	25 % GWh	50 % GWh	75 % GWh	100% GWh
Agriculture	-0.2	-11	-22	-33	-43
Mining	-.04	-211	-415	-610	-797
Services	-0.2	-44	-86	-126	-165
Domestic (High Income)	-0,2	-50	-99	-145	-190

Table A5 Load Curves Analysed from Monthly Values

Sector	Load Factor at Customer Connection Point	Day Peak/Evening Peak Ratio
Agriculture	0.46 – 0.58	1.00
ZCCM Quarries	0.88 0.57	0.67 1.00
Industry	0.40	1.37
Services	0.47	1.52

Notes:

1. The analysis of monthly values show no significant seasonal variations in demand during the year or change in daily load curve profiles.
2. Peak load for total Zambia is 1010 MW and average load is 819 MW.

Table A6 Daily Load Profile

	Day Peak Load 13-14 hours	Off Peak Load 22-06 hours	Evening Peak load 20 hours
Percent of 24 hour average	130 %	70-80 %	Largest Contribution from Domestic Consumers

Note:

1. Possibilities of load shifting from peak to off-peak hours is in the range of 20-25 % of total capacity demand.
2. About 100 MW load shifting should give a flat load curve.

Table A7 Long Run Marginal Cost Future Expansion
(Considering Customer Peak Demand and Energy Consumption at 12 % Interest Rate)

System Level	Peak US $/kW	Energy US cent/kWh	Total US cent/kWh	Load Factor	Simultaneity Factor
Generation	66.7	2.45	3.29	0.9	
330/220 kV	149.9	2.50	4.40	0.9	0.90
66/33 kV	187.1	2.58	6.85	0.5	0.85
11/3.3 kV	219.3	2.64	8.90	0.4	0.85
0.4 kV (Industry & Commercial)	251.4	2.73	9.91	0.4	1.0
0.4 (Res)	182.8	2.73	13.17	0.2	0.70

Table A8 Effect of Load Factor on Average Electricity Prices
July 1996 Tariff Level

Load Factor			0.4	0.4	0.2	0.6	0.8
Tariff	Number Customers	Consumption MWh	ZK/kWh	US cents/kWh (1 US $ = 1250 ZK)			
MD1	2,871	234,131	40.40	3.23	4.47	2.82	2.62
MD2	269	298,733	40.30	3.23	4.73	2.72	2.47
MD3	26	271,981	38.10	3.05	4.81	2.46	2.16
MD4	8	143,694	32.60	2.60	4.25	2.06	1.78

Table A9 Agriculture and Forestry sector Energy Consumption and Contribution to System Peak Demand

Distribution Voltage Level	Energy MWh	kW Per consumer	No. Consumers	Day Peak kW	Evening Peak kW	Load Factor	Total Load Factor	Simultaneity Factor
66-33 kV	90,000	17,600	1	17,600	17,600	0.58	0.69	0.85
11-33 kV	24,000	2,500	2	5,000	5000	0.56	0.77	0.72
0.4 kV	63,219	12.2	1296	15,862	15,862	0.46	0.79	0.58
Total	177,552		1299	38,442	38,442			0.72
Total Contribution to System Peak				27,729	27,729			
Total Zambia 1995/96	6361850		151,702	879,364	908,019			
Losses 10%				86,799	104,235			
Total Zambia 2000/01	7573000		434,314					

Table A10. ZESCO Long Run Marginal Cost Electricity Tariff
Effective February 2001

	A1	B	C1	C2	D
Electricity Tariff Charges **Zambian Kwacha (ZK)** **1 US$=3600 ZK**	**Fixed metering and billing Charge per Month**	**Active Energy Charge per kWh**	**Reactive Energy Charge per kVARh**	**Low Power Factor Reactive Power Charge per Net-kVAR per year**	**Peak Capacity(MD) Charge per kVA per Month**
Un-metered Residential					
L1 up to 2A	4,200 7.2 % of MD1				
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MD4 Capacity above7500 kVA	465,320 800% of MD1	45 53% of MD1			16,847 283% of MD1

Appendix B   Distribution System Factors used in Ele ctricity Pricing

B1.   Distribution Transformer Capacity Sizing

In general, substation transformers should be conservatively sized based on the following formula :

$$kVA_{rated} \geq \frac{(F_g)(F_l)(F_{de})(DL)}{(F_{di})}$$

Where

KVA $_{rated}$ = **Natural Cooling rating of transformer or ultimate forced cooling rating in kVA**

F_g = Growth Factor (1.1 – 1.25)

F_l = Load Factor (0.0 – 1.0)

= (Average load kW per time period) / (Peak load kW in time period)

= (Actual Energy kWh per year)/ (Average Peak load kW x 8760 hrs)

F_{di} = Diversity Factor (> > 1.0) or reciprocal of Simultaneity Factor

= (Σ Individual system Components Max Demands in kW) / (Max Demand kW of whole system)

F_{de} = Demand Factor (0.2 – 1.0)

= (Maximum Demand kW or kVA) / (Total connected load kW or KVA)

DL = Total design load kVA

= Sum of all operating and "designated future" motor, lighting, static and other miscellaneous loads in kVA.

B2.   Distribution Transformer Loss Factor

The loss factor (**F_l**) of a distribution load having a parabolic load curve is given by

Loss Factor = 0.15 Load Factor + o.85 (Load Factor)^2

and the cost capitalized cost **(C)** of losses US $/kW-year is given by

$$C = F_{di} \ \ x \ P(US\$/kW\text{-}year) + \ 8760 \ F_l \ \ x \ E \ (US\$/kWh)$$

E = Cost of Energy and P = Annual Cost of System Capacity

B3. Effect of Load Factor and Power Factor on Peak Capacity Charges

Annual Capacity Factor = (Actual annual energy generated MWh) / (Maximum Avg MW rating x 8760 hours)

A low capacity factor indicates a larger need for excess generating capacity.

Annual Load Factor = (Total annual load energy MWh) / (Avg annual peak load MW x 8760 hours)

= (actual annual energy MWh consumed) / (Max Avg Demand MW x 8760 hours)
= (actual annual energy MWh consumed) / (Avg Max Demand MVA x PF x 8760 hours)
= (0.05 to 0.9)

Load factor indicates, in a rough way, the excess generating capacity that is requires to serve peak loads.

Higher load factors tend to reduce average power costs because the capacity investment costs for equipment are spread over more energy consumption. That is, the more units used and the higher the load factor and power factor (PF), the less will be the capacity fixed cost per unit. This can easily be seen from the following relation.

Avg Peak MD MVA = (actual annual energy MWh consumed) / (Load Factor x PF x 8760 hours)
PF = Load Power Factor at the connection point

On this account it is the aim of every Supply Engineer to make his load factor and power factor as high as possible. Special inducements are generally offered to consumers to be able to do this by way of a special tariff reductions and penalty charges for low power factors. It therefore pays the consumer to install power factor correction capacitors to raise a low power factor to a value between 90 % and 98% .

B4. Variability of Demand Factors

The demand factor defined in Appendix B2 will vary considerably with different types of load as follows:

Electrical Load	Percent Demand Factor
Arc Welders	30
Resistance Welders	20
Lighting	80
Heaters	80
Arc Furnaces	100
Induction Furnaces	80
General Purpose Pumps	30
Continuous Operating Mills	90
Semi-Continuous Process Mills	60

B5. Effect of Diversity Factors on Peak Capacity Charges

The maximum demand made on a generation station , transmission substation and distribution substation determines the size and cost of the installation. The total cost of energy is the sum of the standing charges (proportional to the maximum demand peak kVA capacity) and the running charges (proportional to the active energy used).

The maximum demands of a number of consumers connected to the same substation are most unlikely to occur all at the same time, so that the system maximum demand on the supply or substation is much less than the sum of the maximum demands of the separate consumers. This gives rise to the maximum demand simultaneity factor (coincidence factor) which is equal to the reciprocal of the diversity factor defined in Appendix B2.

Therefore, it is quite clear that the consumer should pay a standing capacity charge per kVA of maximum demand equal to that paid by the station divided by the station divided by the diversity factor.

For example if the average standing capacity charges per kVA of maximum demand and diversity factors for Generation, Transmission and Distribution Are as shown below.

Capacity Standing Charge	MD4 ZK/ kVA/ month	Diversity Factor	ZK/ kVA/ month Divided by Diversity Factor
Generation Capacity	3,000	60	50
Transmission Capacity	4,000	20	200
Distribution Capacity	10,000	5	2,000
Total Charge	17,000		2,250

This calculation supposes that the utmost use is made in Generation, Transmission and Distribution, and in the combination of the diversity factor.

It follows that the encouragement of the diversification of load is likely to cause a much greater economy than even the existence of a high load factor.

This, in fact, is exemplified in the use of water heaters at specified times, during which very low charges are made.

Appendix C
Appendix C1 Mpongwe

Mpongwe						
Meter-Point Year	**Total kWh**	**Total Cost kWh**	**Total MD kVA**	**Total Cost MD kVA**	**Load Factor**	**Total Bill including Fixed Charges and Taxes**
2000	**8827110**	**397258460**	**21210**	**297865800**	**0.57**	**900772021**
1999	**10221590**	**394456650**	**21967**	**270898356**	**0.64**	**863073345**
Munkumpu Sub-Station						
2000	**4973760**	**226952100**	**16836**	**237540372**	**0.40**	**603458520**
1999	**5646840**	**218246040**	**17707**	**217784676**	**0.44**	**566671700**
Lake Pump Sub-Station						
2000	**5075640**	**319107120**	**10314**	**96605245**	**0.67**	**524729164**
1999	**3359440**	**177280970**	**10892**	**88250288**	**0.42**	**344750151**
Mpongwe East Sub-Station						
2000	**9947570**	**448797620**	**27180**	**383845740**	**0.5**	**1055397784**

Appendix C2 Mubuyu Farm

Meter-Point Year	**Total kWh**	**Total Cost kWh**	**Total MD kVA**	**Total Cost MD kVA**	**Load Factor**	**Total Bill including Fixed Charges and Taxes**
2000 **Maize** **Wheat**						 **35688629** **111065306**
1999 **Maize** **Wheat**						 **21628605** **107478338**

Appendix C3 York Farm

Meter-Point Year	Total kWh	Total Cost kWh	Total MD kVA	Total Cost MD kVA	Load Factor	Total Bill including Fixed Charges and Taxes
2000						282208935 1.7% of Total Production
1999						167167173 2.6 % of Total Production

Appendix C4 Maple Hurst, Hybrid, Mutuwila Farms

Meter-Point Year	Total kWh	Total Cost kWh	Total MD kVA	Total Cost MD kVA	Load Factor	Total Bill including Fixed Charges and Taxes
2000 Maple Hybrid Mutuwila						 11832084 199234213 91024905
1999 Maple Hybrid Mutuwila						 131263231 58,701,752

Appendix D

Appendix D1 ESKOM Tariff Structure (South Africa)

TARIFF STRUCTURE		LC 1	SC 2	LR 3	LT 4	BR 5	LRC 6	HRC 7	PP 8
1	**CONNECTION FEE**	X	X	X	X	X	X	X	X
2	**BASIC CHARGE**	X	X	X		X	X	X	X
3	**DEMAND CHARGE**	X							
4	**ACTIVE ENERGY CHARGE**	X	X	X	X	X	X	X	X
5	**REACTIVE ENERGY CHARGE**	X							
6	**VOLTAGE DISCOUNT**	X							
7	**TRANSMISSION % SURCHARGE AFTER (6)**	X							
8	**MONTHLY RENTAL (CAPITAL CONTRIBUTION)**	X	X						
9	**DEPOSIT**			X	X	X			
10	**ADDITIONAL CAPITAL COST CONTRIBUTION**							X	X
11	**CAPITAL COSTS**			X		X			
12	**FIXED CHARGE**								
13	**MAINTENANCE CHARGE**				X				X
14	**METER CHARGE**								X
15	**VAT & LEVIES**	X	X		X	X	X	X	X

PP = PREPAYMENT
SC =SMALL CONSUMER
HRC=HIGH RESIDENTIAL
LR =LAND RATE

LC =LARGE CONSUMER
LRC=LOW RESIDENTIAL
BR =BUSINESS RATE
LT =LIGHTING

Appendix D2 ZESCO Tariff Structure (Zambia)

TARIFF STRUCTURE		L1 L2	R1 R2	COM	SS	MD1 MD2 MD3
1	CONNECTION FEE	X	X	X	X	X
2	BASIC CHARGE					
3	DEMAND CHARGE					X
4	ACTIVE ENERGY CHARGE		X	X	X	X
5	REACTIVE ENERGY CHARGE					
6	VOLTAGE DISCOUNT					
7	TRANSMISSION % SURCHARGE AFTER (6)					
8	MONTHLY RENTAL (CAPITAL CONTRIBUTION)					
9	DEPOSIT	X	X	X	X	X
10	ADDITIONAL CAPITAL COST CONTRIBUTION					
11 12	CAPITAL COSTS FIXED CHARGE		X	X	X	X
13	MAINTENANCE CHARGE					
14	METER CHARGE					
15	VAT & LEVIES	X	X	X	X	X

L1,L 2= UNMETERED
LC=LARGE CONSUMER SC=SMALL CONSUMER
R1=LOW RESIDENTIAL R2=HIGH RESIDENTIAL
COM=BUSINESS RATE SS=SOCIAL RATE

Appendix D3 USA and Canada Tariff Structure

Hydro-Quebec Canada	**Wasco Electric Cooperative (Oregon) USA**	**Clay County Electric Cooperative (Arkansas) USA**
4.9 cents/kWh Residential Customer	5.26 cents/kWh Residential customer	7.8 cents / kWh Residential Customer
Residential	Residential	Rural Residential
Farm	Commercial	Commercial (Small)
General	Industrial	Industrial (Small)
Industrial	Irrigation	Industrial Large
Street Lighting	Others	Irrigation
Others		Other
ANZA Electric Cooperative (California) USA	**Vernon Municipal Light Department (California) USA**	**Distribution Voltages**
15.2 cents/kWh Residential	3.44 cents/kWh Residential	5kV (2.2 – 6),13kV (10–17) 25kV(19 –28), 35kV(29-52)
Residential	Residential	
Commercial	Commercial	**Transmission Voltages**
Industrial Others	Industrial Others	69kV(46-70), 115kV(100-140) 230kV(200-275) 345kV (includes up to 400)

Appendix D4 London Electricity Tariff Schedule (United Kingdom)

Tariff, British Pence		**Standard Rate**	**Economy 7 00h00 – 08h00**	**Evening & Weekend 20h00 – 07h00**
Daily Standing Charge		20.20	24.00	24.30
Unit Rate	Peak	7.56	8.03 (106% of Std)	9.71 (128% of Std.)
	Off-Peak		2.84 (38% of Std)	4.04 (53% of Std.)

Appendix D5 Eskom Miniflex and Ruraflex Tariff Schedule (South Africa)

Tariff, RSA Cents		**Urban Standard**	**Rural Standard**	**Miniflex**		**Ruraflex**	
				High Demand Season	Low Demand Season	High Demand Season	Low Demand Season
Monthly Standing Charge		17,955	17,955	6,320	6,320	37,980	37,980
Demand/kVA		4,133	4,371	N/a	N/a	N/a	N/a
Unit Rate	Peak	7.46	7.90	36.38	32.75	42.27	37.94
	Std.			13.38	12.00	15.96	14.32
	Off-Peak			7.67	6.91	9.28	8.31

Appendix D6 Woodstock Tariff Schedule (Canada)

Monthly Tariff, Canadian Cents.		**Commercial & Ind. < 5MVA**	**Commercial & Ind. > 5MVA**			
			Winter[1]		Summer[2]	
			Peak[3]	Off-Peak	Peak	Off-peak
Energy/ kWhr	First 250 kWhrs	11.6	4.63	3.42	4.02	2.35
	Next 12,250 kWhrs	7.62				
	Next 1,807,000	5.58				
	Rest	3.54				
Demand/ kW	First 50 kW	Nil	15.19		11.07	
	Rest	5.10				

Notes:

1. Winter Period Oct. 1 to March 31
2. Summer Period April 1 to September 30
3. Peak Period 07h00 to 23h00

Appendix E Position and Decisions on Tariff Revision

Appendix E1 ZNFU Position

The Zambia National farmers' Union (ZNFU) stand on the ZESCO tariffs adjustment is that it will raise the cost of production in the agriculture sector. This will make Zambian agricultural produce uncompetitive in the SADC region and COMESA markets. The ZNFU is concerned that the macro focus on agricultural development has been lost. Critical public utilities like ZESCO are now expected to compete with farmers for survival. The farmers are currently operating below break-even and pushing electricity charges higher will lead to the total collapse of the agriculture sector, including the floriculture and horticulture sub-sectors.

Twice yearly the ZNFU has had to present their position to the Energy Regulation Board (ERB). The Union would like the issue of tariffs adjustment to resolved in such a manner that future electricity price increases do not cripple the economic viability and productivity of the whole agriculture sector.

Therefore, the ZNFU is requesting for special tariff considerations for its members that will encourage more efficient utilization of the ZESCO's electrical power system while providing electricity to the farmers at affordable economic prices. Such a tariff should take into consideration time of day, electrical load characteristics, the power supply quality and reliability requirements at different power demand points on a farm. The automatic tariff adjustment formula should be applied to verifiable actual incremental costs resulting from foreign exchange business transactions. In addition, the variables in the formula need to be examined very carefully.

In this way, Zambia would have a stable electricity tariff schedules which would allow realistic long range development planning in the agricultural sector. This would reduce the unnecessarily high electricity bills. The resulting savings would contribute to making Zambian agricultural produce competitive on a sustainable basis.

Appendix E2 ZESCO Position

ZESCO uses the automatic adjustment formula to adjust for inflation and keep tariffs constant in terms of the US dollar equivalent. In part, this was a requirement of the World Bank financing to ZESCO.

Currently the revenues from domestic electricity sales do not cover the total annual average costs of the Distribution and Customer Service Division of ZESCO.

The Management Performance Contract with the Government of the Republic of Zambia requires that the ZESCO tariffs should be based on projected average costs of operations and capital costs for generation, transmission , distribution and supply.

In addition, ZESCO is cognizant of its performance challenges relating to: access to electricity, billing system, energy conservation, emergency response, quality of power supply and voltage stability, and high frequency of unplanned power interruptions.

Therefore, for ZESCO to attain both economic efficiency and technical efficiency in the shortest possible time, it has set the following three primary goals for changes of future electricity tariffs:

1) Increase to ZESCO on a long run marginal cost basis
2) Subsidies for households with weak financial economy
3) Efficient use of electricity and streamlining of operations.

The revised tariff, in part, implements the above goals which will result in electricity price escalation. ZESCO recognises that price escalation is always interpreted by the customer as a negative message. To balance this image, the great advantages with the use of electrical energy to generate benefits and profits is to be emphasised.

Thus, an essential part of the implementation of the new tariffs is information to the customers. It is important that all customers get a comprehensive information of planned changes of prices and other conditions, both in short and long time range. This is of special importance for the agricultural and industrial customers as they often work with budgeted cost and long-term investment profitability calculations.

Appendix E3 ERB Decisions

The ERB has the responsibility to see that the undertakings earn a reasonable rate of return on their investment that is necessary to provide good service, and that the consumer is given affordable quality service. Thus the Board must weigh and balance the needs of undertakings with those of different categories of consumers. The main rulings at the public hearing follow.

1) A three part, lifeline block tariff for residential consumers was approved with minor changes.
2) The entire pricing formula will be reviewed under an all-party settlement initiative to be spearheaded by the Board. This will make the ATAF suitable to the current economic environment by ensuring that it is fair to both consumers and the utility.
3) ZESCO should work out a tariff for farmers that takes into account the time of day when electricity is being used. The proposal must be submitted to the ERB before April 2001.
4) The Board will continue to monitor ZESCO's financial and technical performance through a special reporting system to be introduced .
5) February 1, 2001 is to be the effective date of the new revised electricity tariffs.

Appendix E4 World Bank Mission Observations

The mission made four observations relating to the rulings of the Board, namely:

1) The 16 % tariff increase on average will help maintain theretail tariff level in real terms because the Kwacha has significantly depreciated since the last tariff review in April 2000.
1) The delayed effective date from November 1, 2000 to February 1, 2001 will certainly cause considerable revenue losses to ZESCO.

2) Increasing the threshold of the lifeline tariff from 100 to 300 kWh/month will heavily subsidise some better-off residential customers.
3) Principles of the ATAF (announced by ERB in May 1999) should be maintained in ERB's future reviews.